ANTHRENUS MUSEORUM (COLEOPTERA: DERMESTIDAE), AN EGG PREDATOR OF *LYMANTRIA DISPAR* (LEPIDOPTERA: LYMANTRIIDAE) IN CONNECTICUT AND A REVIEW OF DERMESTIDS AS GYPSY MOTH EGG PREDATORS[1]

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ABSTRACT: Larvae of *Anthrenus museorum* were collected in egg masses of *Lymantria dispar* in Tolland Co., Connecticut, in March 1982. Field evidence and subsequent laboratory rearing confirmed predation on viable moth eggs. In Japan and South Korea, several new collection records and a possible new species of *Trogoderma* from Japan are reported. The first recovery of *Cryptorhopalum ruficorne* in Delaware is included. Dermestids in the role as predators on gypsy moth eggs worldwide are compiled in a table and briefly reviewed. Any impact appears to be directly density dependent and at high moth populations the impact may be significant. This form of egg predation has not been thoroughly studied.

Dermestid beetles (Coleoptera: Dermestidae) are known principally as pests of stored products, carpets, dried animal tissues (e.g. skins, furs, feathers, insect collections), and a wide variety of other organic matter (Griswold 1941; Hinton 1945). A catalogue of the Dermestidae of the world, including distributions, was compiled by Mroczkowski (1968).

The association of dermestid beetles with gypsy moth, *Lymantria dispar* (L.) (Lepidoptera: Lymantriidae), eggs was recognized long ago (Forbush & Fernald 1896; Burgess 1899) but the significance and impact of this association remain elusive. There have been many anecdotal accounts of finding larval dermestids feeding in gypsy moth egg clusters but little has been done to clarify the impact of this predation, with the possible exception of the study by Nonveiller (1959). Usually larvae are found to have hollowed out a portion of an egg mass. Few have determined to what extent this form of egg predation has contributed to gypsy moth egg mortality. In the process of tunneling within an egg mass, disruption of the protective setae covering the egg mass occurs. It has been suggested that this is important since it enhances parasitism by egg parasitoids, e.g., *Ooencyrtus kuvanae* (Howard) (Hymenoptera: Encyrtidae) and *Anastatus japonicus* Ashm. (Hymenoptera: Eupelmidae), by making more eggs in a cluster accessible to these parasitoids (Mason & Ticehurst 1984). Under field conditions, Nonveiller (1959) concluded that dermestids had a significant impact on gypsy moth egg survival under outbreak conditions, sometimes ac-

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counting for up to 50% mortality of viable eggs; many dermestids were also found in old egg clusters where they were clearly feeding as necrophagans and not predators. At lower population levels the impact is greatly diminished (Nonveiller 1959). It appears that mortality of the gypsy moth egg stage due to dermestid predation is directly density dependent; this has yet to be experimentally confirmed.

FIELD COLLECTION

North America: The senior author collected a number of dermestid larvae in egg masses of gypsy moth at Willington, Tolland Co., Connecticut, on March 16, 1982. Egg masses with dermestid larvae were found under the eaves and roof overhang on a building adjacent to gypsy moth infested forests. At least one predatory larva was found in a gypsy moth egg mass on a *Quercus rubra* L. trunk adjacent to the building. As egg masses were scraped off the building, tunneling and apparent destruction of viable eggs were evident. Collected dermestid larvae were returned to the laboratory and allowed to complete development in the presence of the remains of the field collected egg masses or on laboratory reared eggs. In total, 14 adult dermestids were reared from the Willington material.

These adults, subsequently identified as *Anthrenus museorum* (L.)[4] (Coleoptera: Dermestidae), were introduced into pint paper cartons and provided with laboratory reared gypsy moth egg masses. During exposure to fresh gypsy moth egg masses, viable eggs were deposited; subsequently a new generation of dermestids was reared exclusively on gypsy moth eggs. Development of the laboratory reared generation occurred at ambient laboratory room temperatures (ca. 18-26° C.) and emergence of the adults occurred in March, 1983. Thus partial development of the parental generation and complete development of the progeny occurred within one year. This record of *A. museorum* as a predator on viable gypsy moth eggs in Connecticut is the first North American record. It is also the first confirmed occurrence of the species in Connecticut, previous authors often mistaking *A. castaneae* Melsheimer for this species.

Gypsy moth egg masses collected in Newark, Delaware, on April 4, 1983, were isolated in pint paper cartons. The following month, three adults of the dermestid *Cryptorhopalum ruficorne* LeConte emerged, a first record of this association in Delaware, although *C. ruficorne* was reported as a predator of gypsy moth eggs in nearby states (Mason & Ticehurst 1984; Beal 1985).

Japan and South Korea: During the collection of gypsy moth egg masses in our previously reported study (1975-78) of egg parasitism (Schaefer *et al.* 1988), a collection of dermestids was obtained concurrently. Dermestid larvae were isolated and reared on available field collected gypsy moth eggs. Emerging adults were killed, pinned and labeled. Although some of those records

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[4] First identified in 1983 by J. M. Kingsolver, USDA, SEL, Beltsville, MD (now retired).

were published previously (Schaefer, 1980; 1981), all of our dermestid records are included in Table 1.

Deposition of Specimens: A synoptic collection of available dermestid material is deposited in the U. S. National Museum, Wash. D.C., The Carnegie Museum, Pittsburgh, Penna., and in the Gillette Entomological Museum at Colorado State University.

BRIEF REVIEW OF DERMESTIDS AS GYPSY MOTH EGG PREDATORS

In North America, there are relatively few references to the presence of Dermestidae in gypsy moth egg masses (Table 1). Burgess (1899) reported finding *A. verbasci* (L.) larvae feeding on gypsy moth egg masses in Massachusetts in October, and that adults appeared the following May. Hoebeke *et al.* (1985) illustrated and provided a key to identify eastern North American species of *Anthrenus,* including both *A. verbasci* and *A. museorum,* and Griswold (1941) studied the biology of *A. verbasci* in detail. Campbell (1967) stated that unidentified dermestid larvae were occasionally seen preying on gypsy moth eggs in northeastern New York. In central Pennsylvania, Brown and Cameron (1982) listed larvae of *Dermestes lardarius* L. as a predator associated with gypsy moth eggs. Also in Pennsylvania and in West Virginia, larvae of C. *ruficorne* were found attacking gypsy moth eggs (Mason & Ticehurst 1984) and, as mentioned above, P.W.S. confirmed C. *ruficorne* in this same role in Delaware. All these North American records and all other known records worldwide are included in Table 1, which is an updated version of the basic table of predators first compiled by Brown and Cameron (1982).

In other areas of the world, especially in Eurasia, there are considerably more records of dermestid associations with gypsy moth eggs. The most common genera are *Anthrenus, Attagenus, Dermestes, Megatoma* and *Trogoderma.* Of apparent lesser frequency are species in the genera *Globicornus, Ctesias,* and *Zhantievus.* Nonveiller (1959) found six new dermestid species feeding in gypsy moth egg masses and of these, *Megatoma pici* was the most abundant. Interestingly, Nonveiller found that larvae of *M. pici* were fairly mobile and larvae would readily move between different egg masses. All of these dermestid beetles appear highly opportunistic; no doubt any insect egg mass similar to those produced by gypsy moths will be suitable for attack. For example, in India, *Lymantria obfuscata* (L.), often referred to as the Indian gypsy moth, has the same egg laying behavior. Its eggs are reportedly attacked by *"Anthrenus sp.* prob. *museorum",* and an *Orphinus* sp. (Dharmadhikari *et al.* 1985). Howard (1897) and Burgess (1899) record dermestids also attacking eggs of white-marked tussock moth, *Orgyia leucostigma* (J. E. Smith) (Lymantriidae), which are deposited in a hardened foam-like material.

Table 1: World list of Dermestidae reported as predators (or apparent predators) of gypsy moth eggs, *Lymantria dispar* (L.) (Lepidoptera: Lymantriidae).

Species (Alphabetically listed)	Location	Reference/Collector/Year[a]
EUROPE AND ASIA		
Anthrenus museorum (L.)	Japan	Schaefer 1980
	South Korea	Schaefer (1976)
	Japan (Kyushu & Honshu)	Schaefer (1976)
verbasci (L.)	European SSR	Karnozhikii 1957
	Japan (Kyushu & Honshu)	Schaefer (1976)
	Japan	Schaefer 1980
	Ukraine	Kotenko 1982
Attagenus unicolor unicolor Brahm (?) (recorded as *A. piceus* Olivier)	Russia	Nonveiller 1959
unicolor japonicus Reitter	Japan (Kyushu)	Schaefer (1976)
sp.	Japan	Schaefer 1980
	Europe	Thompson & Simmonds 1964[b]
Ctesias serra F.	Yugoslavia	Nonveiller 1959
Dermestes ater De Geer	Europe	Forbush & Fernald 1896
	Azerbaijan	Aliev *et al.* 1974
bicolor F.	Ukraine	Kotenko 1982
erichsoni Ganglbauer	Yugoslavia	Nonveiller 1959
	Bulgaria	Schedl 1936; Karnozhikii 1957; Nonveiller 1959
		Stefanov & Keremidchiev 1961[b]
	Romania	Pirvescu 1978; Teodorescu 1980
	Russia	Shapiro 1956; Vorontsov 1950
		Nonveiller 1959
	Ukraine	Kotenko 1982
	Russia Far East	Kolomiets 1987
lardarius L.	France	Picard 1921; Nonveiller 1959
	Bulgaria	Schedl 1936; Karnozhikii 1957; Nonveiller 1959; Stefanov & Keremidchiev 1961
	Italy	Prota 1966
	Azerbaijan	Aliev *et al.* 1974
	Europe	Burgess & Crossman 1929[b]
	Russia	Shapiro 1956; Vorontsov 1950
		Nonveiller 1959
	Ukraine	Kotenko 1982
	Italy (Sardinia)	Luciano & Prota 1983
undulatus Brahm	Russia	Shapiro 1956; Vorontsov 1950; Nonveiller 1959
	Ukraine	Kotenko 1982
sp.	Japan	Schaefer 1980
spp.	Yugoslavia	Nonveiller 1959
	Ukraine	Zelinskaya 1981

Globicornus nigripes F.	Yugoslavia	Nonveiller 1959
Megatoma conpersa Solskij	Russia Far East	Kolomiets 1987
pici Kalik	Yugoslavia	Nonveiller 1959[b]; 1976
pubescens Zetterstedt	Yugoslavia	Nonveiller 1959
undata L.	Yugoslavia	Nonveiller 1959
	Romania	Pirvescu 1978
Orphinus sp.	Japan	Schaefer (1976)
Trogoderma sp.	Ukraine	Kotenko 1982
varium (Matsumura & Yokoyama)	Japan (Kyushu & Shikoku)	Schaefer (1976)
sp. possibly undescribed[c]	Japan (Shikoku)	Schaefer (1976)
Unidentified	Japan	Howard 1910

AFRICA

Anthrenus verbasci (L.)	Morocco	DeLepiney 1930[b]
vladimiri Menier & Villemant	Morocco	Menier & Villemant 1993
Dermestes lardarius L.	No. Africa	Thompson & Simmonds 1964[b]
Trogoderma versicolor Creitz	Morocco	DeLepiney 1927[b], 1929, 1930[b], 1933
		Nonvieller 1959
versicolor var. *meridionale* Kraatz	Morocco	Hérard & Fraval 1980
sp.	Morocco	DeLepiney 1927[b]
Zhantievus lymantriae Beal	Morocco	Beal 1992

NORTH AMERICA

Anthrenus museorum (L.)	Connecticut	Schaefer (1982)[d]
verbasci (L.)	Massachusetts	Burgess 1899; Howard 1910
Cryptorhopalum ruficorne LeConte	Pennsylvania & West Virginia	Mason & Ticehurst 1984; Beal 1985
	Delaware	Schaefer (1983)[e]
Dermestes lardarius L.	North America	Griffiths 1976[f]
	Pennsylvania	Brown & Cameron 1982
Trogoderma prob. *ornatum* (Say) (listed as *T. tarsale* Melsheimer)	Massachusetts	Howard 1910
Unidentified	New York	Campbell 1967[b]

[a] Years given in parentheses are years of specimen collection. Specimens collected by the senior author in the 1970's were identified by Sadanari Hisamatsu (1977) and/or by John M. Kingsolver (1979). Years not in parentheses refer to date of publication; see Literature Cited.

[b] Cited in Griffiths 1976.

[c] D. G. H. Halstead, *in litt.*

[d] Identified by J. M. Kingsolver (1983) and confirmed by R.S.B., Jr. (1995).

[e] Identified by J. M. Kingsolver (1984), examined by R.S.B., Jr. (1985).

[f] Listed in Griffiths' (1976) table but text does not substantiate a North American record associated with egg masses, however a record coming from a pupal mass is recorded.

We believe that, in time, many other associations will become known as other species of opportunistic dermestids are found to take advantage of the nutritional resources and protected niches represented by individual masses containing hundreds of gypsy moth eggs. This will be especially true as the invading gypsy moth in North America moves into new geographical areas and comes in contact with other dermestid species for the first time.

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